GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

DRAFT FOR Science Team REVIEW

2nd GHRSST-PP Science Team Meeting

NASDA/EORC, Tokyo, Japan, 13th May, 2002.

Summary report

Prepared by Craig Donlon

GHRSST-PP Science Team (ST) meeting

The purpose of the ST meeting was to review quickly and effectively the GHRSST-PP Strategy and Initial Implementation Plan document and identify any significant aspects that require further work. Each Theme leader presented a short review of their activities as summarized in the GHRSST-PP Strategy document that was followed by round table discussion.

GHRSST-PP Science Team

Present:

Craig Donlon	(Chair; EC JRC, Italy)
Hiroshi Kawamura	(Tohoku University/NASDA EORC)
Jim Cummings	(NRL, USA)
Ian Robinson	(SOC, UK)
Pierre le Borgne	(SAF, Meteo France)
Ian Barton	(CSIRO, Aust.)
Nick Rayner	(Met Office, UK)
Chelle Gentemann	(RSS, USA)
Gary Wick	(NOAA, USA)

Apologies:

Chris Mutlow	(RAL, UK)
Peter Minnett	(RSMAS, USA)
Bob Evans	(RSMAS, USA)
Bill Emery	(U. Colorado, USA)

Opening and local arrangements

Hiroshi Kawamura welcomed all of the participants and explained that Doug May would not be attending the Workshop due to illness. Kawamura then gave a general overview of logistics for the meeting identifying Ms. Shiori Kadobayashi as the point of contact for any immediate needs. On behalf of NASDA/EORC Kawamura then invited all present to an evening reception at 6:30 pm.

Review of Agenda

Apologies from Chris Mutlow, Bob Evans and Peter Minnett were given. Craig Donlon then summarized the main purpose of the ST meeting. (see Donlon-ST-agenda-review.ppt) clearly identifying the need for the ST to (a) endorse the general strategy laid out in the GHRSST-PP strategy and initial implementation plan, (b) identify any outstanding strategy issues requiring further consideration and (c) agree on the GHRSST-PP product definitions. Donlon then reviewed the ST Terms of Reference (Annex II) and the position of the ST within the framework of GODAE reminding the ST of their role. A short review of the GHRSST-PP strategy was presented and the current GHRSST-PP data products identified. Donlon noted that he expected the definition of these data products to change significantly by the end of the workshop. Finally, the agenda for the day including a call for any additional AOB topics was presented and accepted by the ST with no change. The ST meeting agenda is provided in Annex III.

GHRSST-PP theme I: User Information Service (UIS) and Distributed Dynamic Dataset (DDD) (Leader: Ian Robinson)

Ian Robinson, leader of Theme I, presented a short review of Theme I activities (see ISR-Theme-I.ppt) within the broad strategy of the GHRSST-PP. He drew particular attention to the fact that this workshop was concerned with the implementation of GHRSST-PP and that this should be the key theme of the workshop and focus of all discussions.

As Theme I is concerned with the concept of a Distributed Dynamic Dataset (DDD), Robinson drew attention to the fact that the DDD is a concept but lies at the core of the GHRSST-PP. He posed the question "What actually is the DDD?" noting that there is considerable overlap between the various GHRSST-PP themes - where do the themes stop and start? The DDD provides the means to expose the strengths and the weaknesses of existing SST data sets because no single data provider has the ultimate data system or data sets. Robinson stressed that the GHRSST-PP needs to target the DDD as a vehicle for data merging that allows users to specify their SST product of choice (possibly tuned to specific applications). He argued that the user should be allowed to choose which data sets are used within a particular GHRSST-PP data product. Theme I could provide a way to generate products driven by application. For example, it could allow users to request products according to accuracy specifications that are distinct from products based on resolution specifications. Several other examples were given underscoring the need to separate the requirements for high accuracy data (climate requirements) from applications requiring better coverage (cloud free) and resolution (general user requirements). He noted that the EU THIRST proposal was targeted at this type of application but was not successful. Nevertheless, the proposal is still viable and can still be used within GHRSST-PP. Donlon suggested that the THIRST proposal should be made available to the Theme 1 working group for comment.

Robinson then reviewed each of the Theme I modules (Module I: User Information Services (UIS), Module II: Distributed dynamic dataset (DDD)) and, in each case, underlined the question of "How were the Theme I thematic modules going to be implemented?" The User Information Service (UIS) module was considered to be fairly straightforward in terms of implementation as this essentially consists of a series of WWW pages linking to the distributed activities within the GHRSST-PP. The DDD is more problematic partly because of its importance at the core of the project, but also in terms of the technical challenges that it poses. The DDD can be seen as a layer on top of all GHRSST-PP activities and may require assistance from data management specialists.

Robinson then referred the ST to reference document (5) "GHRSST-PP Implementation plan v0.2" drawing specific attention to the Work breakdown structure diagram and the specific work packages of Theme I. He suggested that the ST needed to focus and discuss the implementation plan details while bearing in mind the overall GHRSST-PP Strategy document. The strategy is a science overview and what we are concerned with here is a rational implementation of the scientific vision. There is a clear need for the ST to take ownership of the implementation plan rather than leaving it to the Chair to put all of this together. Finally, he proposed that the ST should use the v0.2 implementation plan as a focus of discussion; the ST should decide if the work packages as presented are in fact appropriate.

General discussion

A lively discussion followed the presentation. Bill Rossow noted that there is a need for a table describing the actual Real Time (R/T) data flows that are relevant to the GHRSST PP as there is no current reference for improving SST data within the strategy plan. What data sets are critical to the GHRSST mission (Global or regional? Large scale high spatio/temporal resolution ?) - what is the bare minimum requirement for the GHRSST-PP to succeed in improving current state of the art in SST data production?

Donlon agreed that this table needs to be added to the strategy document and drew attention to table 1.1 of the strategy plan that lists generic data sets identified as important to the GHRSST-PP. It was also noted that ESA/REMSS/NAVOCEANO/NASDA have already agreed to supply the GHRSST-PP with R/T data streams. The ST agreed that such a table is required and that it would identify the strengths and weakness within the GHRSST-PP. However, there is a "delicate dance" between what is practically possible within the existing research and operational framework and the remit of the GHRSST-PP.

Robinson noted that a key role of GHRSST-PP is to consider the best type of data to provide to the user which may require the use of models to help use single point in situ data. Ian Barton reminded the ST that the GHRSST-PP is meant to provide data products that can be used to help demonstrate and improve data assimilation of SST data within GODAE. Hiroshi Kawamura replied that the Ocean Obs. 99 conference explains why we need high-resolution data sets and new products and this is one of the foundations of the GHRSST-PP. Pierre LeBorgne considered that the real time definition of GODAE is poor and is perhaps not applicable to this project because a 24 hour delay is a limit to the usefulness of R/T data sets as data beyond this delay will be superceded by the new R/T data. Jim Cummings agreed stating that there is a clear need at NAVOCEANO for SST data at 6hrs or less for their ocean models.

The discussion them moved to consider GHRSST-PP data streams to be considered in the DDD. Kawamura noted that R/T operational SST sensors are different from the research sensors. There is a new generation of IR/MW sensors but these are not guaranteed for the future and we should e looking to demonstrate the usefulness of available sensors so that follow on missions can be considered properly. From a practical point of view in terms of GHRSST-PP implementation there are two types of data streams:

1. **R/T Regional data**. E.g., LAC AVHRR and Geostationary imager observations
2. **R/T Global data.** E.g., GAC AVHRR, MODIS, AATSR, MW(TRMM/AMSR)

Donlon noted that we are very advanced compared to 3 years ago with many new satellite sensors now in orbit and about to enter operations (e.g. AMSR, MODIS, AATSR), there is new computing power and many new ideas for how best to combine complementary data streams. Robinson noted that there is a diversity of available data sets and GHRSST-PP needs to harness all of the data that has associated technical issues. For example, many satellite data sets are maintained and produced in different data formats (flat binary, hdf, etc). The DDD needs to consider different access/storage protocols although the GHRSST-PP should nominate a preferred data format (hdf, BUFR, GRIB?). This is also desirable from an operational and a scientific viewpoint. Cummings then asked if in situ data sets will be included in the DDD in order to provide error statistics to the GHRSST-PP data products. Donlon replied that this would be the case and the diagnostic data set (DDS) was the obvious place for these to reside with appropriate links to other data via the DDD. Different formats must be considered at all levels within GHRSST-PP but special care should be taken to ensure that R/T output data satisfies user requirements.

The ST agreed that the R/T AVHRR type (wide swath polar orbit) data sets will provide the core of most data GHRSST-PP products due to the global coverage. The main activities within the GHRSST-PP are concerned with the prospect of microwave (MW) and infrared (IR) data merging. However, there is also need to consider R/T regional geostationary satellite instruments on platforms such as MSG, GMS and GOES. Finally, the AATSR sensor should provide a high class of accuracy distinct from the others and in situ data will be used to develop error statistics.

The discussion then moved to consider diurnal signals and their importance within GHRSST-PP data product specifications. Kawamura raised the issue of diurnal stratification noting that this was not a user requirement in Japan (clearly stated in the 1st GHRSST-PP Workshop report). Cummings replied that modeling groups within GODAE would use and need diurnally resolved SST. Robinson commented that people use data in different ways and the ST should be aware that there is a class of user that needs to know about the diurnal thermocline. Cummings replied that this is why the modelers need to have error statistics with the data referenced to a depth/time so that issues such as diurnal stratification can be appropriately considered within the models. Donlon pointed out that the GHRSST-PP should not confuse the technological need to deal with the diurnal thermocline in terms of data merging and analysis methods with a user product requirement: the user may not be concerned with diurnal warming events but GHRSST-PP has to address diurnal variability of SST to assure consistent SST data products. Barton agreed noting that even though users say they don't need data products describing the diurnal thermocline, GHRSST-PP needs to treat the issue correctly so that users get a better SST specified product.

Gary Wick added that properly considering the diurnal signal is a main area where GHRSST-PP can add value to existing SST products.

The ST concluded that the GHRSST-PP data products must account for the diurnal variability irrespective of the users requiring a diurnal product from the point of view of merging complementary data sets. The ST was urged to think about how this would be best achieved perhaps as a data product mask containing phase and amplitude information.

Conclusions:

- A Table of current capability for SST should be added to the strategy document including URL links where appropriate – This should clearly specify the minimum and optimal requirements for the project together with current capability.
- The AVHRR sensor would provide a basic SST data set from which others would be derived in the first instance. Merging these data together with microwave SST data, ENVISAT AATSR data and, various geostationary satellite instrument observations will form the basis for the GHRSST-PP data products.
- While there is not a need within the general user community for a diurnal SST "product", modelers specifically desire this information and a suitable data product (a diurnal mask with phase and amplitude) is required.
- There is a need within the GHRSST-PP to properly consider the diurnal signal irrespective of users in order to properly merge and analyse data.
- A key element of GHRSST-PP is how best to harness the information content of different data sets addressing data formats, access restrictions and translation software – this needs to be written clearly within the implementation plan
- There is a need to review and properly specify the simplistic work packages within theme I which cuts across all other activities within the GHRSST-PP.

GHRSST-PP theme II: Diagnostic Data Set (DDS) (Leader: Craig Donlon)

Donlon presented an overview of Theme II activities (see CJD-Theme-II.ppt) drawing attention to the fact that the diagnostic data set would be a data resource that underpinned much of the methodology development foreseen in the GHRSST-PP for merging and analysis of satellite and in situ data. The DDS is a tool for both operational and research within the GHRSST-PP. The origin of the DDS concept was to establish a globally distributed subset of data that was collectively, of a manageable size to work on merging and algorithm development. The important point is that the DDS sites are well spaced attitudinally and cover the major areas of the ocean (including aerosols, clouds, ice edge etc.). Donlon underlined the importance of the DDS within GHRSST-PP and encouraged the ST to consider how the resource can be coordinated with other Theme activities. For example, the DDS concept may also include the validation of GHRSST-PP data products. A brief overview of the difference between High-resolution DDS, Regional DDS and Global DDS activities was given together with a schematic diagram explaining of how the DDS conceptually links to the DDD. It was stressed that there are considerable advantages to the DDS concept including the ease of data access (the DDS is a "one-stop-shop" open source of satellite and in situ observations) via a common format (e.g., hdf) and interface (e.g., metadata, access protocol). Furthermore, a DDS of manageable globally distributed data chunks makes life easier for both data provider and data user. The DDS interface will consist of a search engine linked to the GHRSST-PP DDS (or GDAC) metadata system. It is foreseen that basic tools for the manipulation and visualization of un-projected satellite data sets will be part of the DDS system.

Donlon stressed that the DDS was primarily a tool for the inter-comparison of data (e.g., bias detection), for long term monitoring of input data (stability of data), for merged and analyzed SST algorithm development, GHRSST-PP product validation and quality control. However, it was important to consider many different data types (e.g., satellite wind speeds, in situ solar and Long-wave radiation or air-sea temperature difference measurements) and thereby encourage the development and understanding of the next generation of multi-sensor algorithms. In this sense, it is not important to have in situ observations at all HR-DDS sites as considerable benefit will be realized by having satellite data alone. Nevertheless, high qualities in situ observations are required at a globally distributed sub-set of DDS locations. The GHRSST-PP strategy foresees this situation by identifying Case 1 (with in situ observations) and Case 2 (without in situ observations) DDS sites.

Donlon then explained that the DDS v1.0 high-resolution sites were preliminary in terms of their location and that the ST should take time to identify key areas where HR-DDS sites should be established. Furthermore, DDS sites are expected to evolve as the project matures. Regional DDS sites should be established in areas that are currently active project areas or address issues of a regional scale (e.g., aerosols/dust form the Sahara or areas of persistent marine stratocumulus clouds). Global DDS data sets target time-space average data (e.g., 1 deg grid cells of monthly mean data) although daily products could also be used. It was emphasized that the 3 DDS data modules (High resolution DDS, regional DDS and Global DDS) are complementary to each other. Donlon asked the secretariat to distribute copies of the v1.0 HR-DDS site locations to the ST for comment urging each member to add/delete/move HR-DDS sites as they saw appropriate. These sites would then constitute a v2.0 HR-DDS within the GHRSST-PP implementation plan.

Donlon then noted that the DDS metadata repository was the backbone of the DDS and DDD concept providing the key to using any data within the GHRSST-PP and required careful thought in terms of the metadata records that should be developed. Standards and emerging/best practices should be adhered to (e.g., use of standards based metadata records and XML as a transport wrapper) but not at the cost of functionality (i.e., metadata records should not be a burden). Finally, Donlon noted that a pilot DDS system has been developed at the European Commission Joint Research Center and was being used to develop a new AVHRR/ATSR skin SST algorithm.

General discussion

Barton commented that the work packages and work plan for the DDS were currently not clear in the Implementation plan v0.2. Donlon referred the team to WP4000 on p10 of the v0.2 implementation plan noting that the DDS was of sufficient importance to warrant a dedicated work package tree. This did require dome work in order to reach an adequate specification but this can only be done in collaboration with the data providers and the udders of the DDS.

BR noted that it was not clear on what basis the v1.0 HR-DDS boxes had been distributed in the Strategy document or why the DDS was so important within the GHRSST-PP. What was the justification for the system and why doesn't the GHRSST-PP just use the global data sets and extract data as required? Donlon replied that the v1.0 distribution was a first definition and was meant to ensure a full latitudinal distribution of sites. Furthermore, the equal spacing of sites can be helpful when developing regional approaches to SST merging and analysis methods. In principle, L1b data would be extracted at source in R/T and pushed to the DDS system together with a metadata record. Both GHRSST-PP merged and analyzed data sets together with lower level data (L1b and L2) will also enter the DDS system. Wick commented that simply having a communal DDS resource is beneficial in itself because there is considerable work for each researcher wishing to use multi-sensor data for developing new methods within the GHRSST-PP. Wick further underlined the importance of the DDS concept for global long-term calibration and validation exercises. Chelle Gentemann noted that the DDS was going to be a valuable tool for microwave SST development and especially for understanding differences between IR and MW data sets and that Remote Sensing Systems could make several data sets (TMI, SSM/I, TMI-VIRS) available to the GHRSST-PP DDS at minimum inconvenience.

Cummings asked if drifting buoys were foreseen in the system. Donlon replied that clearly in certain circumstances this would be desirable but the DDS HR-DDS sites should be maintained independently of in situ observations. Drifting buoys implied moving the location of DDS sites accordingly, which is not desirable. Robinson suggested that the DDS project including drifting buoys was too optimistic without further support form data providers. Kawamura agreed noting that there are significant differences between operational and R&D data feeds both satellite and in situ. The DDS should focus on in situ data at moored buoys as these are quite important for algorithm development, validation and when generating merged SST data (e.g. NGSSTv1.0). It was concluded that if drifting buoy observations were available within a DDS site, they should be used but moving DDS sites to accommodate drifting buoys should not be undertaken.

Ken Casey noted that some DDS sites should be placed in the coastal regions where SST dynamics are strong. Furthermore, some DDS sites should include land in order to monitor geolocation errors in global data products. Other DDS sites could be positioned over coral hot spot regions where problems in terms of understanding SST data has been found: these sites would also have political appeal possibly helping to leverage funding for the GHRSST-PP. The ST agreed but noted that coral reef areas may have a different suite of problems in terms of interpretation – these areas have sub-pixel land areas and possibly strong tidal effects. The ST urged caution in the use of coral reef areas within the DDS. One approach would be to have different DDS data sets for example, regional DDS areas or DDS data defined by application. These could be used together and form a global DDS linked by the DDD. Donlon noted that this would fit with the GHRSST-PP strategy very well but the project should maintain and prioritize a distinct "minimum set" of DDS sites. The position of DDS sites was further discussed and Andy Harris noted that perhaps fewer but larger DDS sites should be defined and positioned to maximize the data capture from various satellite sensors in different orbits. In particular narrow swath instruments such as the AATSR and AIRS are problematic in this respect and there may be few data from these within the DDS. Donlon replied that if this was the case, then this is a feature of those data that is captured by a regular grid of DDS sites. Robinson noted that this would then introduce biases in favor of some sensors.

Ed Armstrong was concerned that the DDS data volume would rapidly become a burden and asked for some example data volumes. Donlon noted that the DDS would be a distributed system linked via a central metadata repository system so that tools such as the Distributed Oceanographic Data Server (DODS) could be used by users to connect and use data. Donlon that 1 years worth of HR-DDS AVHRR GAC L1b data was about 1 Gb storage space based on experience at the EC JRC.

Conclusions

- The DDS is poorly specified in terms of content versus requirements and this needs to be fixed rapidly. The Implementation plan work packages will need to be carefully specified to clearly show how the DDS is created, maintained and used within the GHRSST-PP.
- The number of HR-DDS sites should be focussed on applications that include some coastal sites. Sites should be graded as class I with in situ and class II without in situ data.
- Specification of DDS sites to not optimal and needs to be better considered based on wide consultation with the user and operational communities. In particular the exact location of moored buoys was not well known for many areas of the ocean. A v2.0 DDS location would be drawn up based on the suggestions of the ST as indicated on the v1.0 site position handouts.
- If drifting buoy observations were available within a DDS site, they should be used but moving DDS sites to accommodate drifting buoys should not be undertaken.
- The DDS is a key element of the GHRSST-PP bringing a novel data set to the community at large and should be supported strongly within the GHRSST-PP.
- Regional projects should also be targeted including some DDS sites that include land and others that include "politically sensitive issues".
- The DDS system as written in the strategy document is too complex and needs simplification when the Implementation plan is written.

GHRSST-PP theme Iii: Satellite data integration (SDI) (Leader: Gary Wick)

Gary Wick (GW) Theme III leader, presented an overview of Theme III modules identifying that these were essentially a set of R&D tasks delivering proven methodologies, tools and SST algorithms that will be refined throughout the GHRSST-PP. He noted that much of the R&D effort is now underway in several nationally funded projects including the new generation SST

NGSSTv1.0 (Kawamura et al), diurnal warming studies (Gentemann, Harris and Wick), and the merging of ATSR and AVHRR sensors (Donlon and Pinnock). Theme III was thus very much concerned with how best to coordinate these activities for the benefit of the GHRSST-PP. Wick noted that it was important to properly recognize this in the Work packages described in the Implementation plan. The three main modules of Theme II were then summarized (Module III-i: Reconciling measurements at different depths, Module III-ii: Reconciling measurements at different times, Module III-iii: Reconciling measurements at different spatial resolution, Module III-iv: Ensuring accurate and consistent retrieval of SST from different sensors) and Wick noted that these modules did not easily translate into a clear implementation plan scenario. Furthermore, the Implementation plan v0.2 was far too general. What should constitute the Implementation plan work packages e.g. should we have 1 work package on diurnal cycle, 1 work package on cloud clearing etc?

Wick noted that (analyzed SST data) would be produced using optimal assimilation methods and that there was an important relationship to Theme IV activities. However, the main role of the SDI theme is to assure consistent SST data products in terms of cloud clearing, optimal use of different sensors through satellite data integration. Wick mentioned the possibility of eventually using a common radiative transfer model to merge all data sets and also for the future, will radiance based assimilation techniques be possible allowing simulations retrievals of SST? Wick was keen to assign coordinators to Theme III modules noting once again that the there was a need for close coordination and cooperation with existing SST projects

General discussion

A lively discussion followed starting with Casey asking if there was a simplistic data merging approach currently available? (e.g., just fill gaps in an AVHRR data set with TMI data). Wick replied that this was the original starting approach, but looking at difference maps e.g., between MCSST and TMI reveals significant spatial differences so that such a simple approach is not that effective a method. Kawamura noted that the use of simple models provides a strong tool and this is the basis of the NSSTv1.0. Kawamura noted that it was not simple to merge data and gave the example of diurnal warming within the NGSSTv1.0 scheme. Diurnal variations exist in different places with varying strength depending on local conditions but satellite data sample at different spatial resolutions and at different acquisition times. There is no simple data merging method that can accommodate different data at different times within cycle. Thus the NGSSTv1.0 approach was based on a daily mean (diurnal component removed) “minimum SST” (as a single 24 hr analyzed SST product) but this is considerably different form the 6 hourly diurnally resolved SST product foreseen in the GHRSST-PP. For such a product, a more detailed model will be required to estimate diurnal amplitude based on model data driven by mean wind speed and peak solar radiation and probably in situ observations. Casey wondered if such an approach would be valid globally or if it would be better to have regional implementations? The following discussion concluded that more information was required to assess this (i.e., this is a next step from the simple global implementation which was in fact the core activity of the SDI itself. Donlon noted that this was indeed the case but nevertheless, a set of agreed “version 1.0” methods is required for the Implementation plan and we have to resolve this by the end of the workshop.

More discussion on the characteristics of diurnal stratification and the use of models within the NGSSTv1.0 method followed. Harris noted that a modeling approach was going to be required whatever approach was taken if satellite measurements obtained at different times of the day were to be used with confidence. However, wind sped would be equally important to the SST data sets used in these methods and how would a suitable model cater for satellite wind speed measurements that are unable to provide any information on a wind speed variability? A mean wind speed obtained from satellite data will be poorly specified. One approach would be to use in situ observations together with satellite wind data although in situ wind speed observations are few. Barton highlighted the importance of this point noting that a single burst of high wind speed may destroy any diurnal stratification that has built up over several hours. Kawamura replied that the NGSSTv1.0 provided a daily mean minimum SST because of these problems. Barton replied that without reliable wind speed data a daily mean minimum SST is poorly specified: in low wind speeds there is a problem with diurnal stratification and cool skin effect. Perhaps a better approach would be to use difference values between the maximum and minimum SST relative to a mean SST. Gentemann explained when looking at differences between MW and IR SST they are large. Most of these differences are due to diurnal warming. TMI/Pathfinder differences can be removed by accounting for diurnal warming with ~95% confidence. Thus properly specifying diurnal warming phase and amplitude of SST signals based on the use of daily satellite wind speed and solar radiation is a good approach. The NGSSTv1.0 products are an excellent start in this area but further woirk is required to obtain 12 hourly analyzed fields Furthermore, in the case of TRMM VIRRS and TMI, which are truly collocated, there is lots of scope for research and development in order to provide a suitable methodology. Kawamura replied that the NGSSTv1.0 is a real time product and there is less opportunity to consider details compared to a research environment. Thus, the NGSSTv1.0 is based on a rational approach using satellite data set. Kawamura then explained that the NGSSTv1.0 group are now working on how best to use other data sources such a NWP fields to help develop the approach further. Rossow urged caution when using NWP model data as this could be incestuous and possibly introduce systematic errors if GHRSST-PP data products are to be assimilated by the same models. Donlon noted that recognizing operational limitations is important point because the GHRSST-PP needs to have a v1.0 SDI algorithm that is grounded in the operational world.

Rossow noted that there was a danger in taking a decision to throw away diurnal products produced as intermediary products of the data merging process at this stage as there is so much discussion surrounding the issue, they must be of some value. Donlon agreed that a type of diurnal product would be useful. Harris suggested that a diurnal product based on phase and amplitude would be sufficient. The ST noted that a diurnal product is a derived product and should not be a primary GHRSST-PP data product in its own right. Donlon noted that the diurnal signals could be a contained as a set of flags within the GHRSST-P data products themselves. Cummings replied that the US Navy models produce estimates of diurnal signals and these products could be used to validate GHRSST-PP diurnal warming flags. Robinson replied that this was a good point and that in the future (10yrs) satellite data may be best used to validate models; the GHRSST-PP must make sure that our merged data sets preserve this type of validation capability. A diurnal map could be generated on the fly if the appropriate UIS and SDI tools were available. Kawamura noted that the NGSSTv1.0 is just one way to go and there are others. Perhaps we should reconsider the dynamic generation of products as suggested by Robinson in Theme I discussions? Barton replied that this could be an approach but we needed to have the research conclusions to a point where the modelers can understand the GHRSST-PP data products. There is a need for user outreach in this area.

The discussion then moved to address the question of what benefit does the GHRSST-PP SDI bring to the SST community. Harris noted that most modeling users want a product with error statistics – they are not concerned with the details of how this was generated, but most SST products do not carry pixel based error statistics. This is a main area where GHRSST-PP will bring added value to the SST users. Nevertheless, other classes of user just want a consistent global gridded products. Thus GHRSST-PP should be trying to develop a set of methodologies to address the needs of modelers and general users. Robinson replied that methodologies are OK, but we need a product that is viable for the future. Rossow noted that if GHRSST-PP doesn't produce any new products why have a GHRSST-PP at all? Donlon replied that GHRSST-PP does have to produce new value added products and the NGSSTv1.0 method provides one approach, others include ATSR combined with AVHRR to provide a consistent well calibrated SSTskin data set and the use of MW radiometer s together with IR to address the need for sub-skin SST data. Kawamura noted that regional data sets may be the key to a useful answer. For example, the Japanese group will produce the NGSSTV1.0 anyway and NASDA will provide a data server for AMSR data to GHRSST-PP in real time. Other agencies may take up the approach. The ST concluded that given the number of relevant talks on these subjects,to follow in the workshop, it would be better to postpone this discussion until after the talks.

Kawamura then noted that validation of data products was a feedback to SDI activities and this should be treated with care. For example, validation of NGSSTv1.0 in coastal areas is a problem due to strong SST dynamics making comparison difficult. Robinson replied that this is important for GHRSST-PP; satellite in situ data matchups and sources of error due to match ups (e.g., rms. Differences) can be misleading without careful consideration. Validation of satellite data using in situ observations is a science in itself. Kawamura noted that there is a component of validation in most regional projects and it should be possible to coordinate these activities within GHRSST-PP.

Robinson then moved the discussion to address errors. He noted that MW and IR SST measurements are different and the GHRSST-PP should make sure that the physics and processes are properly considered. We need to have proper error considerations otherwise there would be problems later on. Wick replied that this is still a research topic: Do we know enough to characterize error statistics on each data set to allow satisfactory merging? How should diurnal stratification be represented in GHRSST-PP data products? Clearly they are required but what form should they take? Cummings said that we need errors of the observations not the products and Harris noted that we have to be careful to describe the errors well in order to avoid asymmetry due to diurnal warming and cloud contamination. Cummings noted that there is a definite need for a value to be assigned to each SST grid/pixel value. He noted that Doug May's new cloud tests and error assignment scheme have greatly helped the NAVOCEANO modeling effort.

Wick then summarized the Implementation plan v0.2 Work packages noting that the breakdown of work packages is not optimal at the moment. More work packages were required relating to more specific topics such as development of appropriate error characteristics, cloud clearing etc.

Conclusions

- Simple difference maps (MW&IR) show significant differences between data sets that can be attributed to diurnal stratification and are insufficient in themselves to constitute GHRSST-PP data products.
- Accounting for diurnal variability may not be possible based on a simple daily mean average due to the effect of wind bursts; models may require a highly resolved wind field in time although as a first approximation the approach is good.
- The use of the NGSSTv1.0 is a good first approach for the GHRSST-PP SST1m data products but the scheme needs to be refined to provide 12 hourly analysed SST products.
- We should not archive diurnal products but a diurnal data field within GHRSST-PP data products is required.
- There is a consensus that the GHRSST-PP should produce (analysed) products but these require the generation of intermediate (merged) products as a necessary precursor.
- All products should include an error estimate (and additional confidence (flags) limits) on a pixel basis. Proper error statistics should be preserved in all merged data products.
- The GHRSST-PP implementation plan requires a better specification of the work to be done in terms of data merging and analysis approach.

GHRSST-PP theme IV (Leader: Pierre LeBorgne)

Pierre LeBorgne then reviewed Theme IV activities starting with the question; Is theme IV really necessary? He noted that there was not a consensus on this theme and it was not clear if GHRSST-PP should or should not produce data products. This is related to the discussions that considered if there is a need for merging or analyzing SST data sets because many ocean models can assimilate SST data sets without any additional value added through the merging or analysis process.

LeBorgne explained that data ***merging*** is a specific term and means the superimposing of products over a grid where quality data and error estimates are available for each separate data set at the grid point. For example, a regularly gridded data set of GOES-8 and AVHRR for the Atlantic may contain in some areas only GOES data, in others only AVHRR data but for some areas, both AVHRR and GOES data would be available. Users choose how to handle the duplicity of data in those areas containing GOES and AVHRR data.

Analyzed data is distinct from merged data as data analysis results in the loss of original input stream information at a particular grid point. Continuing the simple example of areas where both GOES and AVHRR are available, an analyzed data field may (for example) take the arithmetic mean of GOES-8 and AVHRR SST to provide a single value for that grid point. In the more general and complex case, optimal interpolation methods can be used to produce an analyzed data set. The important difference between merged and analyzed data products is that error statistics no longer relate to the input data sets themselves, but are a combination of the input data character and the analysis procedure. At the Meteo France Satellite Application Facility (SAF), both merged and analyzed data products are produced operationally.

LeBorgne explained that data merging or analysis "Toolkits" (i.e., stand alone computer code modules) are not applicable to operational agencies who have highly optimized code tuned to specific hardware systems. What operational agencies require are SST data merging and SST data analysis ***methodologies*** .

He then noted that it was unclear who will undertake data merging and analyzing for GHRSST-PP. Would this be done by operational centers within GHRSST-PP or external to GHRSST-PP? Would data merging and analysis be done in real time (within 24 hours of data reception) or in a delayed mode off line context? Furthermore, there were considerable problems to be solved before merging and analyzing multi sensor data and the most important was treating the lack of heterogeneity of complementary SST data in terms of definition and in space/time variability. This was clear from the previous discussions. These are important issues because when producing high-resolution SST fields small time/space differences matter. LeBorgne noted that in particular, microwave SST data pose a problem for high-resolution SST products due to the large field of view and the lack of coverage in the coastal zone. Other issues of concern relate to the many different map projections that are used by different SST data sets. Different data formats, calibration schemes and algorithms also complicate the merging and analysis of data. Finally, but perhaps most importantly, SST data quality flags and confidence data are different across similar SST products. For example, NAVOCEANO uses 3 scale system, MODIS uses a 4 scale system and the SAF a 4 scale system. All of these schemes are qualitative in form (albeit with an inferred quantative estimate): e.g., Clear, probably clear, cloudy.

LeBorgne then explained that the most critical element of the CMS SST analysis procedure (0.1 grid daily North Atlantic SST merging GOES, NAVOCEANO AVHRR and buoy data) is securing the SST data in good time using a reliable data conduit. Reliability is extremely important although differences between data sets are equally important. Thus, in GHRSST-PP there is a need for standard procedures to homogenize different data sets in real time, which is what the R&D component (Theme III) is about. GHRSST-PP should try to adopt a unique definition for each input data stream and define simple conversion rules (e.g. high wind speeds over 6m/s allow a certain confidence in defining SSTskin). Such rules need to include quantitave error rules and values. There is a definite need for a standard approach to the definition and generation of SST quality information. The preferred scheme favors a bias and SD at each grid point.

General discussion

Donlon suggested that the definition of merged and analyzed product is extremely good and helps focus the discussions of this morning. Furthermore, these terms should replace the current Real time and OffLine definitions used in the Strategy document to describe GHRSST-PP data products. Casey agreed pointing out that the merged inputs should be properly defined because these actually form the input to the analysis procedure. Rossow noted that there was still some doubt as to how GHRSST-PP would obtain a 4km data product from the available data presented in the Strategy document as only 8km global SST are available in R/T from NAVOCEANO. Donlon noted that discussions with Doug May indicated that a 4km AVHRR GAC brightness temperature/reflectance product could be made available to GHRSST-PP via the Monterrey GODAE data server.

A lively discussion followed focused on if GHRSST-PP should produce a 4 km merged and analyzed data set or was this too optimistic. If GHRSST-PP fails to produce global 4km resolution data would this be seen as a failure? Kawamura pointed out that oceanographic and atmospheric requirements are different: atmospheric models don't need high-resolution data but instead, they need precise boundary definitions. Oceanography needs the high resolution to detect fronts and eddies (e.g., western boundary currents, upwelling, etc). Donlon noted that some modelers would like to assimilate the fine structures within the SST field and are not concerned with absolute accuracy of the SST data themselves. Many groups have asked for un-interpolated data. Merged data sets should provide this information whereas analyzed data sets should provide an improved mean SST product for more general use (e.g., similar to the uses of Pathfinder SST).

The discussion then considered what exactly the GHRSST-PP data products should be. SSTskin, SSTsub-skin or SSTdepth. Gentemann noted that two products (SSTskin and SST1m) were already available via the ATSR+AVHRR and the NGSSTv10 approaches already discussed. However, Rossow noted that the scope of GHRSST-PP is vastly different if we are going to use global L1b data sets (as in the EC AVHRR and ATSR combination) because of the cloud clearing issue and the calibration issues. Barton replied that GHRSST-PP has to intelligently combine all available SST data to surmount these problems. Gentemann replied that REMSS are currently looking at the best way to include MW SST data into these products. LeBorgne said that CMS had chosen to use the SSTsub-skin definition for their products as this is the only realistic SST for both day and night time conditions. In the day we cannot validate SSTdepth data properly and validation data for SSTskin is too scarce. Donlon asked if a MW SST measurement actually provides a true estimate of the SSTsub-skin or is it an SST that is more weighted towards the skin? Gentemann replied that she was working on this issue now but that essentially, the MW provided an estimate of the SSTsub-skin.

Robinson noted that just from this discussion it was clear that GHRSST-PP needs both SSTskin and SSTsub-skin. Kawamura agreed but cautioned that practical ideas are required: modelers need to have SST structures to work with and these can be masked by diurnal stratification. To get around this the NGSSTv1.0 has adopted the idea of a minimum temperature in the early morning (just before sunrise) as the standard temperature for a dialy mean SST. Rossow replied that the GHRSST-PP should not give a too simple SST product to users and the purpose of the pilot project was to try to advance the field in some way. LeBorgne commented that this was why GHRSST-PP needs to establish rules to convert between SSTskin, SSTsub-skin and SSTdepth using for example, daily mean wind speed from satellites.

Robinson asked who is going to do this suggesting the USNavy, European SAF, and NASDA? LeBorgne replied that the SAF are already producing operational Atlantic area SST data sets in real time which is a considerable effort. Kawamura is providing the Japanese area with the NGSSTv1.0 data products but these two efforts are basically independent from each other at the moment. Robinson commented that the operational objectives of GODAE are OK but the GHRSST-PP is hoping to push forward with new SST data sets. In this sense, GHRSST-PP should be seen as an experimental phase to develop and explore new techniques providing a blueprint for operational agencies (like CMS) to take the new approaches forward. GHRSST-PP should focus on the experimentation and provide a demonstration of what is possible. Operational agencies can then use the results of this exercise in a long term strategy. LeBorgne replied that it was really a question of data availability and priorities. For example, CMS are already committed produce 10km resolution analyzed SST fields as part of its own work but is willing to be "GHRSST-PP compatible", working with GHRSST-PP recommendations and implementing these within the constraints of operations. For a R/T GHRSST-PP this will be a challenge and, without additional dedicated funding, does not seem realistic. For non R/T data there are several areas where we can hope to succeed.

Kawamura replied that NASDA will establish a server for AMSR data and that JMA will establish operational global and regional SST for meteorological forecasting purposes. For GODAE purposes, Tohoku University will work closely to improve SST merging/analysis methodology within the NGSSTv1.0 approach. This is an example of how GHRSST-PP can bring R&D,

operational users and, agencies to work together. We should remember that it is sometimes difficult for satellite agencies to contribute to the community without obvious hooks to hold on to. Donlon replied that this was an important point and that we need to present the data and ideas that we have discussed in a form that will appeal to the agencies. The implementation plan in the veichle for this task and it is critical to the success of the GHRSST-PP that this document is pitched at the correct level. Robinson commented that the GHRSST-PP implementation plan is clearly going to show how the project will bring a benefit to existing agency activities without any competition. Gentemann replied that the GHRSST-PP offers an international framework to bring the SST community together to get collectively better data. At the moment, many SST R&D groups are working on the same problems in isolation which is not optimal so the task should be straightforward in terms of writing the Implementation plan.

Conclusions

- There is a clear distinction between merged (preserve individual error statistics) and analysed data (averaging and loss of input data error statistics)
- Both a merged and analysed data set is required as GHRSST-PP products and the current definition of GHRSST-PP products should be changed from "R/T" and "OfL" to "merged" and "analysed" data products respectively.
- There is a need to clearly define how the merging/analysis will be done through work packages including a proper treatment of data in homogeneity (Use of the DSS approach?)
- SSTskin, SSTsub-skin and SST1m products should be produced by GHRSST and rules to convert between each data type are required.
- We need to ensure that GHRSST-PP advances the field as far as possible. Oceanography requires high space resolution 4-5km and time resolution (better than daily if possible) to resolve dynamical feature. GHRSST-PP data products should thus be "better than 10 km" spatial resolution as a resolution of 4km is too optimistic at this point.
- Operational agencies require methodologies and not "toolkits"

Summary of actions

The chair agreed to work on a summary of the meeting to be reviewed quickly on the 14th before the main workshop as part of the introduction and background session because of the important changes that have arisen in terms of product definitions and the scope of the project.

AOB

Pierre LeBorge asked to step down as Theme IV leader and be replaced by Hiroshi Kawamura which was agreed by the ST.

The Char asked if anyone had any comments on the Biarritz paper that had been prepared for review and noted that significant changes in the paper would be required following the days discussions and the discussions foreseen in during the rest of the workshop. The ST agreed.

The chair noted that for access to ESA ENVISAT data it would be necessary to complete an ESA format proposal to the open call Announcement of Opportunity (AO) proposal via the ESA WWW interface. It was agreed that a single proposal led by the chair including the GHRSST-PP ST members should be prepared and submitted as soon as the implementation plan was in an agreed form (September 2002 at the latest). This would allow access to AATSR data for the DDS and other GHRSST-PP components. The Chair agreed and will prepare the proposal as soon as possible circulating an initial draft to the ST before final submission.

The chair thanked everyone present for an excellent meeting, noting that this would continue briefly the following morning. The meeting was closed at 17:45.

ANNEX I: Attendance list GHRSST-PP 2nd Science Team meeting

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ANNEX II GHRSST-PP Science Team Terms of Reference

GODAE High Resolution SST (GHRSST) Science Team TERMS OF REFERENCE

PREAMBLE

The International Global Ocean Data Assimilation Experiment (GODAE) Steering Team (IGST) has concluded that, for its goals, a significant enhancement of the presently available sea surface temperature (SST) data stream and products is required. In particularly, it noted that the temporal and spatial resolution of existing data sets and products did not meet the requirements of GODAE. The IGST also noted that there were many other requirements for SST products that were not being satisfied as well as they should be.

There are a variety of in situ and remote methods for sampling the surface temperature of the ocean. Some of these techniques sample just the thin surface skin while others measure temperature at some depth below the surface. The physics of temperature variability near the surface are extremely complicated and there is no simple relationship between the different sampling strategies, even under ideal conditions (a well-mixed near surface layer).

There are also many different platforms available for gathering surface temperature information, some maintained operationally and others undergoing development and testing. It is clear that our present techniques for assembling and analyzing these data are far from optimum and that, as a result, we compromise both the coverage and quality of the products provided to users.

GODAE convened a Workshop in November 2000 to consider a Prospectus for a GODAE high-resolution SST Project. The participants of the Workshop concluded that the scientific and technical prospects for a significant enhancement of presently available SST products were excellent and that a High-Resolution SST Pilot Project (the GODAE SST Pilot Project) should be formed under GODAE. A Science Team sponsored by GODAE that would oversee the drafting of a detailed strategy and Implementation Plan would guide the Project.

The following Terms of Reference have been agreed for the Science Team:

(i) Based on the conclusions of the Workshop, develop a set of objectives/goals and a Strategic Plan for the GODAE SST Pilot Project;

(ii) Based on the actions agreed at the Workshop, develop an Implementation Plan for the GODAE SST Project including (a) a set of objectives and strategy, as developed under (i), (b) a set of actions and work to be undertaken by the Project, (c) a schedule for actions and work, and (d) a defined set of outcomes. As agreed at the Workshop, the actions shall include testing and validation of sea temperature measurements, assembly of sea temperature data sets and associated data exchange and serving, analyses of data, and required research and development.

(iii) Provide scientific guidance to, and as appropriate receive advice from, the International GODAE Steering Team on the scientific and technical issues associated with the implementation of the Project and on the use of products by GODAE.

(iv) Develop an international consortium to undertake the development and implementation of the Project, including its final transition into an operational system.

(v) Provide advice and guidance on scientific and technical innovations relevant to the Project.

(vi) Liaise as appropriate with other groups associated with the global ocean observing system, including the SST Working Group and Surface Flux Project (SURFA) of the Ocean Observations Panel for Climate.

(vii) Provide regular reports on progress to the International GODAE Steering Team.

SCIENCE TEAM (January 2000)

Craig Donlon (Chair; EC JRC, Italy: radiometer m'ments, satellite m'ments)
Bill Emery (U. Colorado, USA: radiometer and other in situ m'ments)
Hiroshi Kawamura (Tohoku University/NASDA EORC; Japan, Satellite SST and coastal applications)
Jim Cummings (NRL, USA, operational use)
Ian Robinson (SOC, UK: all rounder)
Pierre le Borgne (SAF, Meteo France: operational high-resolution products)
Peter Minnett (RSMAS: Pathfinder, Satellite products)
Ian Barton (CSIRO, Aust.: ATSR, radiometer m'ments)
Nick Rayner (Met Office, UK, climate user perspective and liaison to climate SST WG)
Chelle Gentemann (RSS, USA, Microwave satellite SST)
Chris Mutlow (RAL, UK, IR satellite measurements)
GODAE Representative (N. Smith or P. Traon)

Annex III Agenda for the 1st GHRSST-PP Science Team Meeting, 13th May 2002.

Time	Title	Leaders
09:00	Opening, welcome and local arrangements	Hiroshi Kawamura
09:15	Review of agenda	Craig Donlon
09:30	GHRSST-PP Theme I overview and discussion	Ian Robinson
10:45	Coffee break	
11:00	GHRSST-PP Theme II overview and discussion	Craig Donlon
12:30	Lunch	
14:00	GHRSST-PP Theme III overview and discussion	Gary Wick
15:30	Tea break	
15:45	GHRSST-PP Theme IV overview and discussion	P. LeBorgne
17:00	Summary, conclusions and identification of actions	
17:40	AOB (Science team membership, Biarritz presentation)	Craig Donlon
18:00	Close	